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Why Research Into the History of Geosciences?

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Introduction

Study of the history of various sciences is rather heterogeneous. Some disciplines, such as medicine, mathematics, and astronomy, have numerous noteworthy compendia and even specialized journals where papers on the history of these sciences can be published.

The situation in geophysics, meteorology, and other subdivisions of the geosciences is far less favorable. This neglect is an outcome of a dogma of autonomy that is essentially oriented toward progress in understanding, without much reference to historical developments. But even the geoscientists cannot ignore that the phenomenon 'science' must be viewed in the context of sociological processes. In the initial stages, sociologists and some philosophers, in the context of the general theory of perception, began research into the development of scientific thought, but the geoscientists and other natural scientists contributed very little. It has since become clear that research on these topics requires historical assessment and more insight. The development of the 'science of science' is directed toward understanding and explanation of the complex human involvement in science, not only in the sense of theorizing about the scientific processes but also in sociological, political, and historical context [*Kuhn*, 1973; *Burrichter*, 1979; *Sandkühler and Plath*, 1979].

Such studies require profound knowledge of many disciplines. The history of science can contribute to a better understanding of these individual disciplines and their interaction toward a better understanding of the overall phenomenon, 'science.'

Opportunities for Historical Research in Geosciences

A number of investigations in recent years have made it clear that for better insight, meteorology and geophysics cannot neglect historical reviews. The problem is that geoscientists, as a rule, are not acquainted with the methods of history and philosophy. This raises the question of how historical studies in these fields can be promoted. I believe the American Geophysical Union and the International Union of Geodesy and Geophysics can be of notable assistance.

It is rather evident that historical questions have not found a place in AGU meetings. The AGU journals, *Eos* excepted, have no space for contributions of historical material in the particular sciences. Why is this so? There seems to be no lack of interest because there were several attempts to activate some historical research in the AGU framework. Two measures would be helpful to promote such work:

(a) Have invited lectures on these topics at AGU meetings.

(b) Offer publication opportunities in AGU journals.

The dilemma is rather clear: A geophysicist or meteorologist who wishes to present historical research does not know where and how. The meetings are reserved for presentations of current research results. There is hardly time for history of science, something that ought to be remodied to offer some opportunities for pertinent papers. But far more difficult is the problem of publication. Where should such papers be published? The traditional journals for the history of science, such as *Isis, Centaurus, Journal for History of Astronomy, Sudhoff's Archiv, NTM-Zeitschrift für Geschichte der Naturwissenschaften*, are not read by geoscientists and certainly not subscribed to by the geophysical-meteorological institutions. This raises the question of what is a suitable journal, i.e., is it responsive to needs of the geosciences? While astronomy has such a specialized journal, there is no counterpart in the geosciences.

There are a number of potential topics for geoscience history. Let me cite several. It is clear that historical weather observations are of importance to modern climatological research [*International Conference on Climate and History*, 1979; *Landsberg*, 1980*a*]. This involves not only extensive literature study but also archival work, including manuscripts and letters. It seems to me equally important to learn about the instruments used for the appropriate reconstruction of the data and also information about the observers who collected the data. This should include biographical studies via the use of original literature and correspondence. The climatological studies need broadening into the field of hydrology. In that field, considerable ancillary work has been done by publication of a source collection by *Welkinn* [1958–64]. Thanks to the support of the well-known geophysicist and meteorologist Hans Ertel (1904–1971), Welkinn was able to study a large number of original sources, covering many centuries that reveal much about climate and hydrology. These were published in four substantial volumes, 1958–1964.

The auroras offer another example of how modern research and historical science studies converge. Many current studies of auroras refer often to Hermann Fritz (1830–1893), who published the well-known 'Verzeichnis beobachte Polarlichter' (Catalogue of Observed Polar Lights; Vienna, 1873). For Scandinavia, Sophus Tromhöll (1851–1896) also presented a large catalogue of auroras (Catalog der In Norwegen bis Juli 1878 beobachteten Nordlichter, Jacob Dybwald Publ. Co., Christiana, Norway, 1902). It seems quite clear that the discussions about the so-called Maunder Minimum [*Gleissberg*, 1977; *Schröder*, 1979; *Landsberg*, 1980*b*] require further reconstruction of old auroral data. In scrutinizing old weather diaries, *Landsberg* [1980] found additional auroral observations not catalogued by *Fritz* [1873]. Moreover, these studies show the change of science concepts through time. In the beginning of the modern period (16–17th century), auroras were regarded as myths, miracles, or inexplicable metaphysical events which were beyond physical explanations by earthbound humans. It is rather intriguing to reflect on the interpretations of these reactions by the psychologist Carl Gustav Jung (1875–1961), who conjectured that the existential threats and anxieties of individuals on earth were projected into the sky. This is also reflected in the early pictorial presentations where, around the core of a natural phenomenon, these anxieties were artistically illustrated. Hence the ancient pictures of sky manifestations always show scenes of death, warfare, storm, and distress. Such aspects have relevance to the development of the geosciences in a historical framework [see, e.g., *Jung*, 1958; *Amstutz*, 1976].

The march of thought in the gradual development of geosciences is also worthy of historical investigation. The appearance of hypotheses, the acceptance of theories and their testing, as well as the gradual changes in concepts can often be understood only in connection with knowledge of the originating research personalities. The progress in theoretical meteorology recalls the sequence of creative

Tobias Meyer (1752–1830), professor of physics at the University of Gottingen.

Sophus Tromhöll (1851–1896), a Norwegian scientist, published a comprehensive auroral catalog for Scandinavia

leaders such as V. Bjerknes (1862–1951), L. F. Richardson (1881–1953), C. G. Rossby (1898–1957), and H. Ertel (1904–1971).

Noteworthy also has been the development of hypotheses about the constitution of the interior of the earth. This pitted physicists against geologists in the 19th century and geophysicists against cosmologists in the 20th. The large pertinent literature has been reviewed in several essays by *Brush* [1977, 1980].

What measures are necessary?

The understanding of the growth processes of natural sciences requires historical reflections. In addition to the disciplinary research it is essential to promote studies that elucidate the context of discovery in the sciences. This will involve topics which, by use of critical historical methods, will explore the higher-order circumstances leading to growth in geophysics and meteorology. In this context, let me pose a simple problem: What led to the establishment of geophysics (and meteorology) as a separate discipline? *Ertel* [1953*a*] had pointed out that the subdivisions of geophysics that existed in the 18th century did not develop in a straightforward way. Shortly after the death of G. W. von Leibniz (1646–1716), as Ertel noted, the problem of a precise determination of the figure of the earth prompted rapid advances in geodesy, astronomy, and cosmogony. According to Ertel, a new phase in the development of geophysics started with Alexander von Humboldt, when meteorology, climatology, hydrology, geomagnetism, and seismology separated from the framework of geography and became separate subdisciplines. In modern times the economic aspects led to rapid developments in applied geophysics, and the interaction of practical requirements with pure research are of interest in the growth of the geosciences [*Ertel*, 1953*b*].

Many generations of researchers of all nations have participated in the various phases of development of meteorology and geophysics. Yet it was not only individual scientists who advanced the science, as in other disciplines [*Kuhn*, 1973; *Zilsel*, 1976; *Sandkühler and Plath*, 1979], but also the great international programs, including the International polar years, the International Geophysical Year, the Global Atmospheric Research Program, etc. Also important were sponsoring institutions, including academies of sciences, which had, for example, a decisive influence on the devel-

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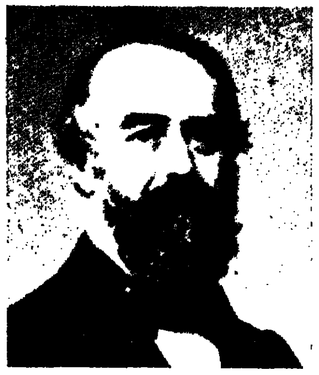
Hermann Fritz (1830–1893), founder of modern auroral research.



Rudolf Wolf (1816–1893), Swiss astronomer and pioneer of solar physics.

opment of climatology [*Landsberg*, 1964]. These institutions also supported the observations of the consequences of the Krakatoa eruption (these observations being inaugurated by the Royal Society in 1883–84), the Norwegian Aurora Program, and others.

It must astonish geophysicists that the origin of geophysics as an independent discipline and even the source of the word 'geophysics' is not fully clarified [*Kertz*, 1979]. Many of the highly controversial problems of environmental research are geophysical in nature and require assessment of observations taken in the past, much of which need historical studies to ascertain validity.

Bases and Sources for History of Geophysics and Meteorology

Besides the knowledge in printed works, it is also indispensible to obtain archived documentation as well as information on instruments used in geophysical work. There is a need for production of bibliographies of the older literature, as is presently done through the 'Meteorological and Geoastrophysical Abstracts.'

Particularly important is the accession and preservation of correspondence. In recent years I have carried on some pertinent studies and had to find that for many important scientists *no* documents are at all available. This is an immense loss for research. Equally important is the collection of the transactions of committees and the administrative files pertaining to establishment of projects and institutions. Also essential are undisclosed materials for personal histories, autobiographies, and pictures that may throw light not only on scientific but also sociological aspects of science history. Finally a comment about historical instruments: They need to be rehabilitated and recalibrated to ascertain their accuracy. It may help in the reconstruction of long observational time series, which remain of contemporary interest [Weber, 1972].

This essay has been written not only to acquaint a large circle of geophysicists with the necessity of historical aspects in geophysics but also to stimulate interested colleagues to contribute to the history of the geosciences through their own writings. The group on history established in the International Association for Aeronomy and Geomagnetism (IAGA) deserves the ardent support of researchers in the field, and establishment of similar commissions or subcommissions in the other associations of IUGG is to be much desired. It is hoped that many geoscientists will use their influence to foster the historical aspects of their respective fields.

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I am indebted to H. E. Landsberg for translation help, useful hints on literature, and for stimulating my interests in the history of science. I am grateful to libraries in Zürich, Frankfurt, Oslo, and Göttingen.

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Wilfried Schröder is a member of the IAGA History Commission His main interest is in the physics of the upper atmosphere (including noctilucent clouds), solar-terrestrial physics, and the history of geophysics and meteorology of the 14th–19th century, which has led him into many detailed studies of noctilucent clouds, mesospheric circulation, and long-term observation of auroras in middle latitudes. In 1975 he published a book on noctilucent clouds, entitled *Entwicklungsphasen der Erforschung der Leuchtenden Nachtwolken*. His new book, *Disziplingeschichte als Wissenschaftliche Selbstreflexion der Historischen Wissenschaftsforschung*, deals with the history and philosophy of geosciences and will be published later this year. He is currently engaged in an edition of the scientific correspondence of Emil Wiechert and in writing a book on the development of history of auroral research. He is interested in all phases of the history of geosciences and the philosophy of science.

News

Improved Weather Satellite

The second of three improved geostationary operational environmental satellites (GOES) was launched May 14 for the National Oceanic and Atmospheric Administration (NOAA). The National Aeronautics and Space Administration (NASA) launched the satellite from the Kennedy Space Center, placing it in orbit at an altitude of 36,000 km (see figure).

Ultimately, the spacecraft will replace an older and similar satellite that monitors the eastern half of the United States and Canada, all of Central and South America, and much of the Atlantic Ocean. The new satellite will watch hurricane development and movement in the Caribbean and provide data on the Gulf Stream and crop killing frost for mariners and Florida citrus growers, respectively.

Government and private weathercasters will depend upon data from the satellite, also called GOES East, for weather forecasting and a number of other uses.

A twin satellite, GOES West, provides similar data on the western portion of the United States and Canada and much of the eastern Pacific Ocean. It is positioned above the equator.

The third geostationary satellite is scheduled for launch during early 1982.

GOES-E Mission

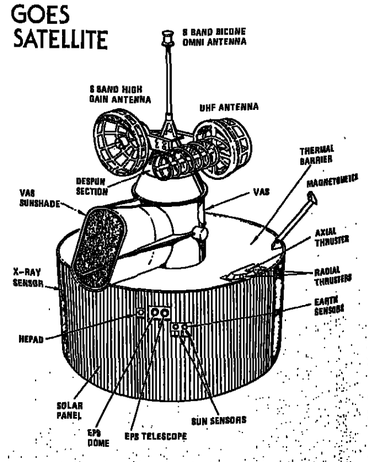
GOES-E is the seventh spacecraft in the SMS/GOES series placed into Earth-synchronous orbit to provide near continual, high-resolution, visual and infrared imaging over large areas of North and South America and surrounding oceans at least every 30 minutes; to collect environmental data from up to 10,000 remote observing platforms on land, in the ocean, and in the air; to measure energetic solar particle flux, X rays, and the strength of the earth's magnetic field; and, to broadcast centrally prepared weather and satellite information.

GOES-E, like its predecessor GOES 4, contains an experimental, advanced type of meteorological sensor that not only observes the traditional visible light and infrared images of cloud formations and motion but also, on command, temperature variations with light in the atmosphere, and it will map the distribution of water vapor in the air. This instrument is called the visible infrared spin-scan radiometric atmospheric sounder (VAS) and was shown to have significant meteorological use as a geosynchronous temperature sounder during its initial experimental runs with GOES 4 between October 1980 and January 1981.

Two GOES satellites presently are operational: one at 135°W, observing North America and the Pacific Ocean to west of Hawaii, and a second at 75°W, observing both North and South America and the Atlantic Ocean. They are at altitudes of approximately 35,800 km and are in circular orbit traveling at about 11,000 km/h.

Instrumentation

The spacecraft on-board subsystems include VAS; the space environmental monitor (SEM), which includes a magnetometer, a solar X ray telescope, and an energetic particle monitor, designed to provide direct quantitative measurements of the important effects of solar activity for use in real time solar forecasting and subsequent research; the data collection system (DCS), which provides communications relay from data collection platforms on land, at sea, and in the air to the command and data acquisition station (CDA) and the interrogation of platforms from the CDA via the satellite; the telemetry, tracking and command (TTC) subsystem, which uses *S* band frequencies for transmission of wideband video data to the CDA, for relay of "stretched" data from the CDA via the spacecraft to facilities operated by NOAA's National Earth Satellite Service in Suitland, Md., and for transmission of weather facsimile data to local ground stations equipped to receive *S* band automatic picture transmission (APT) data.



Data Acquisition and Distribution

Unprocessed VAS data is transmitted via the S-band system to the 18.3-m dish antenna at the Wallops Island, VA, CDA. The CDA processes the incoming data in a synchronizer/data buffer, which reduces the data rate about 16 to 1 for simplification of data transmission. The CDA processes and retransmits this 'stretched' data back to the satellite. The lower resolution infrared data are formatted in special computers for analog transmission via 3-kHz telephone lines directly to the satellite field services stations and to the central data distribution facility.

Satellite field services stations are at Camp Springs, Md.; Miami, Fla.; Kansas City, Mo.; San Francisco, Calif.; Honolulu, Hawaii; and Anchorage, Alaska. They receive a standard 'menu' of imagery on a half hour or more frequent basis, day and night, for analysis and retransmission to National Weather Service offices and other uses via dedicated telephone lines. [Sources: NASA, NOAA]—*PMB*

McGetchin Award Funds Students

The McGetchin Volcano Fund will support volcanology field work for three students this summer. Established last year, the fund honors the late Thomas McGetchin, former director of the Lunar and Planetary Institute in Houston.

This summer, Mark S. Wigmosta, a senior at the University of Washington, will research the dynamics of the Toutle River mudflows triggered by the eruption of Mount St. Helens on May 18, 1980. Tanya Furman, a junior at Princeton University, will examine a Sierra Nevada zoned granodioritic pluton that displays a tonalitic rim. Douglas Coelho, a Cornell University senior, will study field stratigraphy and nature of postglacial ash deposits of Adak Island in Alaska.

Alternates, also chosen by the fund's executive committee are John Spurney (Kent State University), Tom Brikowski (University of Oregon), and William F. McDonough (Sul Ross State University).

Inquiries about the fund should be addressed to McGetchin Volcano Fund, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.

Acid Rain Measurements

The United States and Canada have launched a project to determine whether the methods they use to measure acid rain produce compatible results. Apparently, the U.S. and Canadian findings may not be comparable because of differences in the way they collect and analyze data.

The U.S. separately collects precipitation from snow and rain as well as dry, windblown material. The samples are gathered and analyzed weekly. The Canadians use instruments that collect only water. They gather and test their samples monthly.

The instruments being used by the two countries have been placed at three sites in both the U.S. and Canada. Investigators from each country are testing the samples collected for such major contributors to acidity as sulfates and nitrates. The analysis is expected to reveal any differences between the two methods of collecting and analyzing data.

Colorado State University is conducting the U.S. instrument studies under a NOAA contract. A Canadian government agency, Environment Canada, is performing its study. The Illinois State Water Survey will analyze rain samples collected here.

Collectors have been placed at a National Weather Service site in Caribou, Maine; an agricultural experiment station in Marcel, Minn.; and Glacier National Park, Montana. Environment Canada has provided sites at Lethbridge, Alberta; Mount Forest, Ontario; and Kejimkujik, Nova Scotia. [Source: U.S. Dept. Commerce]—*PMB*

Finalists Chosen in Shuttle Student Project

Ten finalists from 191 semifinal entries have been selected in the first national Space Shuttle Student Involvement Project, a joint venture of NASA and the National Science Teachers Association. The objective of the project is to stimulate the study of science and technology in grades 9 through 12 by engaging students in a competition to develop experiments suitable for flight aboard the Space Shuttle.

Interdisciplinary teams of teachers, scientists, and engineers reviewed more than 1500 proposals; grouped them into 10 geographic regions; and selected the semifinalists. Regional conferences for the semifinalists were held this spring at various NASA field centers.

Semifinalist proposals were then judged by a national team which selected the 10 finalists on the basis of individual scientific engineering merit for potential flight aboard the shuttle.

The 10 national winners and their teacher-advisors will attend a special space shuttle conference in August at Kennedy Space Center, Florida. The students will receive instructions and advice on how to prepare their experiments for payload assignment and review the procedures for integrating their experiments into a specific space shuttle mission. Finalists and teachers will tour the Kennedy Space Center facility and will view the shuttle *Columbia*, in preparation for its second flight in October.

To broaden participation in the program, NASA is encouraging U.S. industrial firms and other groups to sponsor student winners and assist them in transforming winning proposals into experiments. Industries or other organizations interested in serving as a sponsor should write to Glen P. Wilson, Acting Director, Academic Affairs Division, NASA Headquarters, Mail Code LC-16, Washington, D.C. 20546.

The sponsor should be prepared to assign a company scientist to work with the student as well as provide necessary funding for student travel, hardware development, and other costs related to pre- and postflight analysis and reporting. Student experiments will receive a thorough preflight review and safety analysis by NASA, in a procedure similar to the review and analysis given to operational payloads.

In some cases, where a sponsor cannot be found or where the student proposal closely parallels a professional experiment already planned for a space shuttle mission, NASA may arrange for the student to work with a principal investigator as part of an existing research team.

In other cases, minor modifications of professional experiment operations or the collection of special data from existing instruments may be made to accommodate the student proposals. In all cases, NASA will make every effort to see that the student receives sufficient information to write a final report.

Winning national Space Shuttle Student Involvement Project experiments will be assigned to specific shuttle flights as the experiments are ready, as space is available, and as future shuttle flights are confirmed.

Assisted by the sponsor and/or a NASA advisor, the student will analyze the data returned from the experiment and prepare a final report. All scientific data from the student experiments will be in the public domain and made available from the National Space Science Data Center at NASA's Goddard Space Flight Center, Greenbelt, Md.

A second Space Shuttle Student Involvement Project contest will open in September with regional conferences to be held in March 1982 and student winners selected in May 1982. NASA plans to increase the number of student winners for this competition from 10 to 20 finalists. [Source: NASA]—*PMB*

Geophysicists

Roy A. Bailey has been appointed coordinator of the Volcano Hazards Program at the U.S. Geological Survey's National Center. He was project chief of the Long Valley Geothermal Mapping Project before the appointment.

Dagmar R. Cronn, assistant professor and research chemist at the Washington State University's chemical engineering department, received a Class II national fellowship from the W. K. Kellogg Foundation.

New Publications

Turbulence in the Free Atmosphere, 2nd ed.

N. K. Vinnichenko, N. Z. Pinus, S. M. Shmeter, and G. N. Shur, Plenum, New York, xiii + 310 pp., 1980, $49.50.

Reviewed by Donald H. Lenschow

This second edition translation contains a wealth of information on observational investigations of atmospheric turbulence, particularly measurements from aircraft, mostly in the Soviet Union. The observations extend from a few meters above the surface to well into the stratosphere. Although a somewhat narrower focus is implied by the book title, boundary layer observations are discussed as well (although not within the context of surface or mixed layer scaling parameters).

The first three chapters set the stage for the rest of the book. The first chapter discusses in rather cursory fashion a few of the theoretical concepts for the observations discussed later. The discussion is not very rigorous and relies heavily on an eddy diffusivity ('K' theory) to relate momentum flux to the mean wind shear. In discussion of a critical Richardson number, for example, turbulence dissipation is ignored and the transports of heat, momentum and turbulence energy are all assumed to depend upon the same value of K. The second chapter discusses measurement techniques, mostly involving aircraft. The discussion includes estimating turbulent gusts from vertical acceleration measurements and aircraft response characteristics, airborne Doppler radar measurements of ground speed and drift angle, and measuring air velocity by use of hot-wire and sonic anemometers, vanes, and differential pressure probes. Remote sensing techniques (e.g., radars) are mentioned only in passing, with little discussion of the techniques and no examples of their capabilities. There is no discussion of the more modern aircraft systems that have been utilized in the West during the past decade which incorporate inertial navigation systems (INS) to measure aircraft position, velocity, and attitude angles. By combining these systems with air speed and flow angle sensors, air motions can be measured from an aircraft over essentially all frequencies of interest with an accuracy and resolution that can far exceed open-loop gyroscope-accelerometer and Doppler navigation systems. The third chapter discusses in considerable detail techniques and interpretation of spectral analysis.

The rest of the book discusses theory and observations of specific types of turbulent motions and conclusions that can be drawn from them. Turbulence intensity and spectra in stratified atmospheric layers, including the unstably stratified boundary layer, are presented in chapters 4 and 5. It is somewhat disappointing, however, that in these and other chapters no attempt is made to generalize the results in terms of the variables that generate turbulence. Rather, much of the discussion is qualitative, and quantitative results are mainly statistical rather than physical. For example, to specify the vertical distribution of turbulence, values of the averaged turbulence transfer coefficient are presented as a function of height. Values of this derived coefficient (which, as the authors note, can vary by 4 orders of magnitude) are obtained from aircraft flight performance parameters, acceleration data, and mean lifetime of the load increments. Nevertheless, an impressive list of observational results, mainly from the Soviet Union, is cited.

The next three chapters deal with turbulence and turbulent interactions associated with convection (both in clear air and cloud) and waves (gravity-shear and mountain, as well as rotors and turbulence in the lee of mountains). The background discussion that sets the stage for the observations that follow is clear and readable. It does not, however, summarize the current state of knowledge in these areas. Furthermore, there is no mention of numerical modeling or laboratory simulations of convection and mountain waves which, in recent years, have provided data for comparison with observations.

Chapter 9 differs from the rest of the book in that it deals with the effects of turbulence on aircraft. This includes a discussion of the scale of turbulence affecting aircraft flying at different speeds, the assessment of turbulence intensity by pilots, the frequency of turbulence encountered at different altitudes, and the time and space variability of turbulent zones. For example, the authors estimate on the basis of several studies that a characteristic time scale for duration of turbulence at some fixed point in the upper troposphere is about 5 hours. The rules of thumb and case descriptions make this probably the most interesting and least outdated chapter in the book.

The final chapter discusses larger-scale turbulence, including the question of whether or not a spectral gap occurs in the free atmosphere (they conclude probably not) and a discussion of the turbulence energy budget in clear-air turbulence zones.

In several respects, this edition is inferior to the first edition. The excellent introductory chapter in the first edition by J. Dutton, which provided a complementary perspective on both theory and observations of turbulence, as well as an additional extensive list of references, is not included in this edition. Furthermore, the basic structure and conclusions of the book have not changed. In part this is because later observations have not significantly changed the picture. However, very little updating has actually been done. For example, of the 224 references, only 18 are after 1971. In addition, although the translation and technical aspects of the book are satisfactory, additional errors have crept into the second edition. On page 217, for example, reference is made to work by Ackerman and by Malkus without including them in the references; in the first edition, they are included. In the second edition, the references are listed in the text by author and date, and are not alphabetized in the back; in the first edition they are listed in the text by author and date, and are alphabetically listed in the back.

In summary, the book is a useful reference for workers in the field to extensive observational work carried out in the Soviet Union before the early 1970's. However, it no longer represents the current state of the art in many areas of turbulence research. I would not recommend it as a basic text for gaining an understanding of atmospheric turbulence. Furthermore, the second edition is not distinctly better than the first edition.

Donald H. Lenschow is with the Atmospheric Analysis and Prediction Division, NCAR, Boulder, Colorado. The National Center for Atmospheric Research is sponsored by the National Science Foundation.

The Scientific Ideas of G. K. Gilbert: An Assessment on the Occasion of the Centennial of the United States Geological Survey (1879–1979)

Ellis L. Yochelson (Ed.), *Spec. Pap. 183*, Geological Society of America, New York, 148 pp., $17.00.

Reviewed by William Benson

"If G. K. Gilbert isn't the best geologist this country has ever produced, he surely is the one to beat for the title." Thus spoke one of my early mentors on the U.S. Geological Survey, and nothing I have since read, seen, or heard persuades me otherwise. Harold Urey, fresh from the discovery that Gilbert had anticipated by 50 years many of Urey's own ideas about the moon, marveled both at Gilbert's breadth and at his knack "for being right," for right he was on almost all of the varied phenomena toward which he turned his agile mind. Though not so stated (nor perhaps so-planned) this theme pervades *Special Paper 183*. As Hunt states (p. 25): "His accomplishments are especially impressive when viewed in the perspective of the status of geologic knowledge at the time. . . ."

Gilbert's long and illustrious scientific career was completely intertwined with the beginnings and the early decades of the U.S. Geological Survey, and it seems fitting that the Survey's centennial include a reprise of Grove Karl Gilbert. Such is the purpose of this volume.

The Gilbert commemoration was originally planned as a symposium for the 1979 annual meeting of the Geological Society of America. But Gilbert's many contributions defied compression into any half-day session. Those who attended the symposium, therefore, will find in this volume as many new papers as those they heard in San Diego.

In addition to Yochelson's engaging preface, the volume comprises 14 chapters, two on Gilbert, his career and his methods, and 12 on his varied contributions to science. Just the list of chapter titles (condensed and paraphrased below) is impressive:

1. A great engine of research, S. J. Pyne
2. Gilbert's contributions to glacial geology east of the Mississippi, G. W. White
3. Gilbert on laccoliths and intrusive structures, C. B. Hunt
4. Gilbert's studies of faults, scarps, and earthquakes, R. E. Wallace
5. Gilbert's Lake Bonneville studies, C. B. Hunt
6. Pioneering work of Gilbert on gravity and isostasy, D. R. Mabey
7. Gilbert and the moon, Farouk El-Baz
8. Gilbert and ground water, A. F. Agnew
9. Gilbert—Bedding rhythms and geochronology, A. G. Fischer
10. Gilbert and the original barrier shorelines, J. C. Kraft
11. Gilbert and iceberg-calving glaciers, Meir and Post
12. Techniques and interpretations: Gilbert's sediment studies, L. B. Leopold
13. Gilbert's geomorphology, Chorley and Beckinsale
14. Analogies in Gilbert's philosophy of science, D. B. Kitts

Indeed the only subsets of geology that did not come under Gilbert's analytical scrutiny were petrography, paleontology, and stratigraphy (though one might make a partial case for stratigraphy in view of his work on bedding rhythms). The scope is all the more remarkable when one realizes that nearly 20 years of his midlife were so taken up by administrative duties that his research was all but abandoned. As Powell's de facto deputy, Gilbert acquitted himself nobly as an administrator, but geologic research was the loser.

Even long-time admirers of Gilbert may discover new tidbits in this set of papers. How many, for instance, know that in the 1890's he tried (unsuccessfully) to persuade the Carnegie Institution of Washington to sponsor a "deep drill hole for geophysical research"? Or that his Presidential Address to the American Association of Geographers is the first U.S. paper to deal seriously with earthquake prediction? Or that this paper suggests all the major components of our modern programs? That he even proposed a version of the gap method for locating future quakes? These and many more await the reader.

Gilbert's exemplary literary style is not treated separately, but shows through in the quotations from his papers. As any Gilbert fan knows, he wrote as clearly as he thought, well realizing both the value of accurate communication and the fact that sloppy rhetoric may often conceal imperfect logic. In reply to a friend who had inquired how some recent graduates were faring on the Survey, Gilbert wrote a pithy: "Their geology is all right; teach them to write better English." The admonition obviously bears repetition today.

If *Special Paper 183* has a defect it is the uneven style of the papers, an inevitable consequence of any collection of individual efforts. A few, notably those of Charlie Hunt and Bob Wallace, are sprightly enough to rank with Gilbert's own prose. Most of the others are clear and readable, but a couple are ponderous and laborious. No, I'm not going to tell you which, because even they are worth reading.

Historical or commemorative volumes are more often displayed on shelves and tables than are read. This one deserves a better fate. It has a lot of interesting information, not only about G. K. Gilbert and his factual discoveries but about his wonderfully rational methodologies as well. Who knows? Reading this book may even inspire a trek to the library to sample the original Gilbert, a completely rewarding experience in itself.

William Benson is with the National Research Council, Washington, D.C.

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Research Seismologist. The Alexandria Laboratories of Teledyne Geotech invites applications from Ph.D.-level seismologists to work on problems related to the comprehensive nuclear test ban treaty negotiations. Applicants should have background in such topics as theoretical seismology, seismic data analysis, seismic data gathering, advanced scientific computing, and computer systems. To apply please send your resume to Jean Hall, Personnel Department, Teledyne Geotech, 314 Montgomery Street, Alexandria, Virginia 22314.
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Plasma Theorist. Depending on the availability of funds, the Center for Atmospheric and Space Sciences, Utah State University, could have a one year, postdoctoral position in theoretical plasma physics. Candidates should have a Ph.D. degree and a background in nonlinear plasma physics and computer modelling. The appointee will primarily be involved with the development of both 1-D and 2-D numerical models of double layers and electrostatic shocks. Please send a resume and the names of three references to R. W. Schunk, Physics Department, Utah State University, Logan, Utah, 84322. (Tel: (801) 750-2974). Application deadline is June 30, 1981. Position available August-September, 1981. Salary range commensurate with experience.
Utah State University is an affirmative action/equal opportunity employer.

Research Position in Chemical Oceanography. California Institute of Technology, Division of Geological and Planetary Sciences. The position of research fellow is being offered at Caltech for research in oceanography. Investigation of the isotopic composition of neodymium and rare earth abundances in sea water and sediments is now being carried forward. The mechanism of injection of REE into sea water will be studied. The differences in $^{143}Nd/^{144}Nd$ in various water masses (Piepgras *et al.* Earth and Planet. Sci. Lett. *45*, 223–236 and Piepgras and Wasserburg, Earth and Planet. Sci. Lett. 50, 128–138 (1980)) is now being carried forward as an exploratory venture in order to determine the origin and chemical behavior of REE in the ocean and the potential use of $^{143}Nd/^{144}Nd$ as a tracer. The laboratory facilities for sample preparation and analysis are fully functional and will be available. Applicants should have training in oceanography and a good perspective on general physical oceanographic models.
Send resume and references to Professor G. J. Wasserburg, Lunatic Asylum, California Institute of Technology, Pasadena, CA 91125.
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Sedimentologist or Sedimentary Petrologist/University of California, Santa Barbara. Applications are invited for a tenure track appointment in soft rock geology to be filled in 1981–82. Rank dependent on qualifications and experience but preference will be given to the assistant professor level. Applicant should normally have a Ph.D. and strong field-orientation and quantitative background. The candidate will be expected to develop a strong research program in clastic sedimentation as related to basin analyses. The candidate will also be expected to teach at both undergraduate and graduate levels and interact with students and faculty of the department, particularly in the general areas of clastic diagenesis, volcanic processes, paleomagnetics, as well as field geology. Additional duties may include teaching physical geology and summer field geology.
Please send resume, other documentation of abilities, and four letters of recommendation by August 31, 1981 to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. Telephone (805) 961-3156.
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Crustal Seismology/Princeton University. Candidates with an interest in any of the following are invited to apply for research staff appointments:
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Applicants should send curriculum vitae and a list of three references to:
Robert A. Phinney
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Visiting Lecturer in Geophysics. Geology Department seeks one year visiting lecturer 1981–82 to teach exploration geophysics and assist with operation of earthquake laboratory (includes WWSSN Station). Require Ph.D. or nearly completed Ph.D. Apply to the Geology Department, University of Montana, Missoula, MT 59812. Deadline August 1, 1981. Telephone (406) 243-2341.
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Research Seismologist/Solid Earth Geophysics. ENSCO, Inc. in Springfield, Virginia is seeking a Program Manager/Research Seismologist to support an expanding program in solid earth geophysics. Research areas will include: seismic network data processing associated with the detection, identification and location of natural and man-made seismic sources; earthquake characterization and source mechanism studies; explosion source characterization; and empirical studies using near field and far field seismic data. Experience in theoretical and observational seismology at regional and teleseismic distances, is highly desirable. Experience in digital time series analysis is desirable. Ph.D. in seismology is highly desirable, however, M.S. level with experience in earthquake and explosion seismology will be considered. Salary and benefits are extremely competitive. Resumes along with salary requirements should be submitted to the Personnel Department at the address below, Attention Code SAS, ENSCO, Inc., 5408-A Port Royal Road, Springfield, VA 22151.
Equal employment opportunity/AAP.

Seismology. Research associate position anticipated (September 1, 1981), telemetry monitoring project in Virginia. Problems focus on seismicity and neotectonics in the state. Prefer M.S. geophysicist with thesis in observational seismology, but others considered. Applications, transcripts and two letters of recommendation to: Dr. G. A. Bollinger, Seismological Observatory, VPI&SU, Blacksburg, Virginia 24061. Deadline for receipt of applications is August 1, 1981.
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Mineralogy and Petrology. Applications are invited for a faculty position at Weber State College, effective September 1981. This is a permanent faculty position with rank, salary, and tenure track status determined by qualifications. Responsibilities include teaching undergraduate courses in mineralogy, petrology, and geochemistry and some combination of mineral deposits, structural geology and introductory geology. Ph.D. preferred. WSC is a large (10,000 students) undergraduate college with a strong geology program graduating about 10–15 majors per year. The college is situated in northern Utah at the boundary between the Rocky Mountain and Great Basin Provinces and adjacent to the Overthrust Belt. The Department is well equipped for field-oriented teaching and research. The closing date for applications is July 1, 1981. Applications, including evidence of teaching proficiency and the names of three references should be sent to S. R. Ash, Chairman, Department of Geology/Geography, Weaber State College, 3750 Harrison Blvd., Ogden, Utah 84408.
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Graduate Students Research Assistantships, St. Louis University, Paleomagnetic Laboratory. Two positions are open for paleomagnetic research work conducted under NSF sponsorship. The positions are for one year and are renewable. The candidates are expected to apply simultaneously for admission to graduate school to pursue studies leading to a MS and/or Ph.D. degree in geophysics. For more information, contact: Dr. S. A. Vincenz, Department of Earth & Atmos. Sciences, St. Louis University, P.O. Box 8099-Laclede Sta., St. Louis, MO 63156, Telephone (314) 658-3128 and simultaneously, Dean of Graduate School, St. Louis University, 221 N. Grand Blvd., St. Louis, MO 63103.

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Meetings

Joint Oceanographic Assembly

The recently published second bulletin for the Joint Oceanographic Assembly includes a general schedule of sessions, registration information, and a registration form. Scheduled for August 2–13, 1982, at Dalhousie University in Halifax, Nova Scotia, the assembly is sponsored by the Scientific Committee on Oceanic Research (SCOR), the Commission for Marine Geology, the International Association of Biological Oceanography, the International Association of Meteorology and Atmospheric Physics, the Engineering Committee on Oceanic Resources, and the Canadian National Committee for SCOR.
To receive the bulletin and to be included on the list for future mailings, contact Leo O'Quinn, Executive Secretary, Joint Oceanographic Assembly 1982, 240 Sparks Street, 7th Floor West, Ottawa, Ontario K1A 0E6, Canada. ☒

Nonurban Troposphere Symposium

The second Symposium on the Composition of the Nonurban Troposphere will be held the week of May 25, 1982, in Williamsburg, Va. Objective of the meeting is to present the available information on the nonurban troposphere. The symposium is cosponsored by AGU, the American Meteorological Society, and the National Aeronautics and Space Administration.
Contributed papers are being solicited on the following topics: background and nonurban measurements of tropospheric gaseous and aerosol species; sources and sinks of tropospheric gases and aerosols; interactions of tropospheric gases and aerosols; transport of tropospheric species; stratosphere-troposphere exchange of trace species; models of nonurban troposphere; and interpretation and significance of the composition of the nonurban troposphere.
Deadline for reviewer's abstracts (200–400 words) and shorter abstracts (100 words) for publication in the bulletin of the AMS is October 15. Direct abstracts and questions to Jack Fishman, Program Coordinator, NASA Langley Research Center, Mail Stop 401B, Hampton, VA 23665. ☒

2nd U.S.-Japan Seminar on 'High-Pressure Research: Applications in Geophysics'

The second U.S.-Japan seminar on 'High-Pressure Research: Applications in Geophysics' was held in Hakone, Japan, January 12–15, 1981, under the auspices of the U.S.-Japan Cooperative Science Program between the Japan Society for the Promotion of Science (JSPS) and the U.S. National Science Foundation (NSF). The coconvenors were Syun-iti Akimoto (Japan) and Murli H. Manghnani (USA). The first such seminar was held in Honolulu, Ha-

wall, in 1976. Like the Hawaii seminar, the Hakone seminar was a tremendous success.

Twenty-two participants and observers from the U.S., 36 from Japan, and one each from Australia, the Republic of China (Taiwan), the USSR, Germany, and France attended the seminar. Some 47 papers were presented during the seven scientific sessions, covering a wide spectrum of recent advancements in the field. The areas emphasized were: the state of the art of high-pressure science and technology, crystal chemistry and phase transitions, shock wave results, and application of the various high-pressure experimental data to elucidation of the geophysical and geochemical nature of the earth's interior, in keeping with the seismic data and petrological models. The seminar provided the participants and observers a unique opportunity for discussing new data and ideas. The seminar also opened further avenues for the Japanese and U.S. scientists to cooperate in scientific endeavors.

The proceedings of the seminar will be published in a book 'High-Pressure Research in Geophysics' (S. Akimoto and M. H. Manghnani, editors) by the Center for Academic Publications, Japan, at the end of 1981.

This meeting report was edited by Peter Bell from information supplied by the convenors.

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Aeronomy

[illegible]

Electromagnetics

0720 Electromagnetic Theory
MULTIMODE PROPAGATION IN ANISOTROPIC OPTICAL WAVEGUIDES
D. K. Paul (Gordon McKay Laboratory, Harvard University, Cambridge, Massachusetts) and R. K. Shevgaonkar

Using far from cut-off approximation ($2a/\lambda_0 >> 1$) we have derived elegant expressions for the characteristic equations and their relevant solutions to determine the guided wave features of an optical waveguide having an axial dielectric anisotropy. Also, the attenuation constant has been calculated following the concept of a complex permittivity in a lossy medium. For TE, TM as well as hybrid modes studied here, the results computed by the approximate method show very good agreement with those of the exact analytical solutions. The dependence of the power carrying capacity and attenuation on the waveguide parameters highlights the usefulness of the dielectric anisotropy in optical waveguides.
Rad. Sci., Paper 1S0141

0733 Remote sensing
ESTIMATION OF SURFACE TEMPERATURE VARIATIONS DUE TO CHANGES IN SKY AND SOLAR FLUX WITH ELEVATION
S. Hummer-Miller (U.S. Geological Survey, Box 25046 Federal Center, Stop 964, Denver, Colorado 80225)

Sky and solar radiance are of major importance in determining the ground temperature. Knowledge of their behavior is a fundamental part of surface temperature models. These two fluxes vary with elevation and this variation produces temperature changes. Therefore, when using thermal-property differences to discriminate geologic materials, these flux variations with elevation need to be considered. From a representative set of field observations, it was found that flux variations with elevation can cause changes in the mean diurnal temperature gradient from -4° to -14°C per km evaluated at 2000 m. Changes in the temperature-difference gradient of 1°–2°C per km are also produced which is equivalent to an effective thermal-inertia gradient of 100 W $s^{1/2}$ m^{-2} K^{-1} per km. Thus, exposed bedrock on topographic ridges will appear to have a lower thermal inertia due to the additional effect. (Solar and sky fluxes, elevation effects, remote sensing).
Geophys. Res. Lett., Paper 1L0802

0760 Plasmas
A LABORATORY EXPERIMENT ON EM BACKSCATTER FROM FARLEY-BUNEMAN AND GRADIENT DRIFT WAVES
M. J. Alport (Dept. of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242) N. D'Angelo and H. L. Pécseli

Results are reported of a laboratory experiment on Bragg backscatter of 3 cm microwaves by turbulent waves driven by the Farley-Buneman and gradient drift instabilities.

The present work is the third in a series of laboratory experiments performed to test, under controlled conditions, prevalent ideas on EM scattering by equatorial and high-latitude ionospheric waves and irregularities.
J. Geophys. Res., Blue, Paper 1A0823

0773 Remote sensing
REMOTE SENSING OF MUON VARIATION SPECTRA AND INTERPLANETARY INHOMOGENEITIES.
M. El-Raey (Department of Physics, Fac. of Science, University of Alexandria, Alexandria, Egypt.) and S. Gaber

The similarity between the general remote sensing integral equation and Dorman's equation relating secondary to primary muon variation spectra, has been pointed out and exploited. Primary muon variation spectra and parameters of interplanetary field inhomogeneities are remotely sensed by a nonlinear inversion technique, using two different coupling functions. Results are compared to those obtained by the spectrographic technique and interpreted in terms of interplanetary field fluctuations. Based on relationships among kernels of the integral equation, optimisation of location and orientation of measuring stations, becomes possible. (Remote sensing, muons, interplanetary inhomogeneities).
J. Geophys. Res., Blue, Paper 1A0809

0780 Scattering
THE EFFECT OF GRAVITY WAVES ON SPECULAR ECHOES OBSERVED BY THE POKER FLAT MST RADAR
K. S. Gage (Nat'l Oceanic & Atmospheric Admin., Aeronomy Laboratory, Boulder, CO 80303) D. A. Carter and W. L. Ecklund

This paper presents an analysis of a gravity wave event near the tropopause as seen by the vertically looking antenna of the Poker Flat, Alaska, MST radar. The observations are presented as time series of vertical velocity, signal power and spectral width. These parameters are found to oscillate in a systematic fashion that illustrates the effect of gravity waves on the specular echoes. This is seen most clearly by examining the changing appearance of the Doppler spectrum with the phase of the gravity wave. The principal result is that specular echoes are observed only at certain phases of the wave. Examination of a large sample of data shows that more generally the occurrence of gravity waves tends to destroy specularity. The decrease in the magnitude of specular echoes can be parameterized by the width of their Doppler spectra.
Geophys. Res. Lett., Paper 1L0719

Izvestiya Physics of the Solid Earth
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Geomagnetism and Paleomagnetism

2510 Dynamo theories
SATURN'S MAGNETIC FIELD AND DYNAMO THEORY
J. Todoeschuck (Applied Geophysics Laboratory, Department of Mining & Metallurgical Engineering, McGill University, 3480 University Street, Montreal, Quebec, Canada H3A 2A7) D. Crossley and M. Rochester

Observations have shown that Saturn's magnetic field is remarkably axisymmetric and strongly dipolar. On reviewing three possible explanations for the field generation process we view a Braginskii nearly axisymmetric dynamo model as compatible with both the power requirements and the tilt angle in a large Saturnian core. If the core is sufficiently small then a mean field dynamo becomes a more likely candidate, whereas if both these models fail an axisymmetric dynamo based on compressible flow may be possible. (Dynamo theory, Saturn, planetary interiors, magnetic fields).
Geophys. Res. Lett, Paper 1L0190

2510 Dynamo theories
ROTATION OF THE INNER CORE
D. Gubbins (Bullard Labs. Dept of Earth Sciences, Madingley Rise, Madingley Road, Cambridge CB3 OEZ, England)

We cannot observe the magnetic field inside the Earth's core directly but there is likely to be a large toroidal part of 10 - 100 Gauss which, together with the dipole component, could produce a magnetic torque on the inner core that tends to rotate it. Estimates based on dynamo calculations give torques of 10^{19} N. m. which is large enough to accelerate the inner core to the westward drift velocity of .2° per year within a few days. Presumably some equilibrium has been reached in which the inner core rotates with constant angular velocity and experiences no net torque. This rotation should have significant consequences for dynamo calculations because it is a very effective method of stretching field lines, and it helps to drive differential rotation in the liquid outer core. The core is modelled by two solid spheres permeated by a uniform field of 5 Gauss representing the dipole. The inner sphere is free to rotate relative to the outer sphere. When a torque of 10^{19} N.m. is applied to the inner sphere it reaches equilibrium with a steady angular velocity corresponding to a rotation period of 2300 years, which is similar to the westward drift speed, and a toroidal field of about 100 Gauss is induced. The inner sphere can also undergo torsional oscillations with a period of about ten years which may be related to the observed secular variations.
J. Geophys. Res., Red, Paper 1B0413

2550 Time variations, diurnal to secular
[illegible]

... the radial and horizontal components of the surface fields were calculated using various assumed conductivity parameters in the core and in the mantle.
It is concluded that most spherical harmonic models of the Earth's magnetic field do not include enough terms to properly describe the field of core sources with periods of tens of years. These short-period variations are especially important in describing the secular variation. [illegible]

Hydrology

[illegible]

... is produced by vertical subsidence, while the other half by the horizontal displacement. Hence, the vertical subsidence is only approximately half the value obtained in non-coupled models which neglect horizontal displacement. A numerical example demonstrates these conclusions.
Water Resour. Res., Paper 1W0086